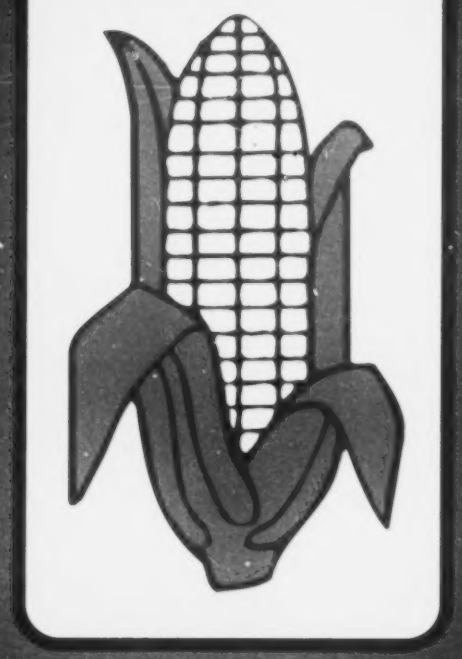

CORN 1992 ANNUAL

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Cover photography by Gregory Thorp

Foreword

Eight years shy of the 3rd millennium, the world treats fantastic technological advances as *blasé*. Five centuries ago dramatic changes were neither as frequent nor as 'vious. But they happened nonetheless; for precisely 500 years ago an explorer returned to the "civilized" world with maize.

Since 1492, corn has profoundly changed the world. One of Earth's three most important grains, corn sustains life in Africa, Asia and the Americas. Corn refiners, centered in the U.S. but positioned worldwide, meld corn and cutting-edge technology to produce results as spectacular and yet as utilitarian as any satellite downlink or cellular phone conversation.

Our industry continues to find new ways to make better use of corn. Corn sweeteners provide low-cost energy. Starch-based bulking agents and fat substitutes create more flavorful and nutritional food products. Corn refiners now make citric acid, pharmaceuticals, polymers, unique industrial adhesives and chemical bonding agents. And of course, they make fuels which hold the promise of America never again having to risk her security on vulnerable sources of petroleum.

500 years after corn entered world trade, the 1992 **Corn Annual** explores the industry's prospects for an even greater role in tomorrow's global market. We cannot predict the complexion of new world trade agreements, but we hope the following articles will show you the exciting horizons facing corn refiners—once the world's traders take down their barriers.

On behalf of the CRA's members, I offer a special thanks to U.S. Secretary of Agriculture Edward R. Madigan and his fellow contributors, not only for their articles but also for their active efforts to reinvigorate world trade. One of them, H. Thomas Reed, spearheads indu. ry innovation both as president of Penford Products, Inc., and chairman of the 1992 Board of Directors of the CRA. All of us connected with the CRA appreciate Tom's commitment, leadership and skill.

Personally, I want to recognize and thank the extraordinarily capable CRA staff. Individually and as a team, their contributions, too, have enhanced the position of U.S. corn refiners as world market participants.

Terry L. Claassen
President

Member Companies and Plant Locations

ADM Corn Processing
(A division of Archer Daniels Midland Company)
P.O. Box 1470
Decatur, Illinois 62525
Plants: Cedar Rapids, Iowa 52404
Clinton, Iowa 52732
Decatur, Illinois 62525
Montezuma, New York 13117

American Maize-Products Company
250 Harbor Plaza Drive
Box 10128
Stamford, Connecticut 06904
Plants: Decatur, Alabama 35601
Dimmitt, Texas 79027
Hammond, Indiana 46320

Cargill, Incorporated
P.O. Box 9300
Minneapolis, Minnesota 55440
Plants: Cedar Rapids, Iowa 52406
Dayton, Ohio 45413
Eddyville, Iowa 52553
Memphis, Tennessee 38113

CPC International Inc.
International Plaza
P.O. Box 8000
Englewood Cliffs, New Jersey 07632
Plants: Argo, Illinois 60501
Stockton, California 95206
Winston-Salem, North Carolina 27107

Minnesota Corn Processors
400 West Main Street, Suite 201
Marshall, Minnesota 56258
Plant: Marshall, Minnesota 56258

National Starch and Chemical Company
10 Finderne Avenue
Bridgewater, New Jersey 08807
Plants: Indianapolis, Indiana 46221
North Kansas City, Missouri 64116

Penford Products Company
(a division of PENWEST)
P.O. Box 428
Cedar Rapids, Iowa 52406
Plant: Cedar Rapids, Iowa 52406

Roquette America, Inc.
1417 Exchange Street
Keokuk, Iowa 52632
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A. E. Staley Manufacturing Company
(a subsidiary of Tate & Lyle, PLC)
P.O. Box 151
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Plants: Decatur, Illinois 62525
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Corn Refining: An Upbeat Outlook, a Positive Example

by H. Thomas Reed
Chairman, Corn Refiners Association, Inc.

Set against the backdrop of 1991's sagging economy, the corn refining industry's performance in 1991 demonstrates a record of achievement which is the envy of many industries. Refiners increased shipments and corn usage, expanded into new products and launched new plant construction.

New Products from Corn

Every corn wet miller showed growth by introducing new products or entering new product lines.

Starch-based fat replacers made the news, with entries by American Maize-Products Company, National Starch and Chemical Company and A.E. Staley Manufacturing Company.

ADM Corn Processing's fermentation plant came on-stream, making feed additives from refined corn feedstocks, and Cargill Incorporated took its first step into ethanol production.

Penford Products Company broadened its line of starch-latex copolymers for paper coatings and has expanded that technology into textiles, paper size presses, and other paper applications. Minnesota Corn Processors entered the carbon dioxide market.

This list only suggests the potential still to be explored. New projects which will help realize even more of the potential in corn are on the drawing board. For example, Cargill, Incorporated is exploring the production of lactic acid polymers as a new product in the degradable polymer market. American Maize-Products Company is coming to market with new lines of hybridized specialty corn starches.

Refiners expanded product lines and added plant capacity in 1991.

New Plant Capacity

While corn refiners expanded their product lines, they have also added to plant capacity during 1991. A number of significant additions for products like crystalline fructose, high fructose corn syrup, dextrose and starches were undertaken during the year, such as Penford's 30 percent expansion of its starch facility. Other expansions are still in the works, including, at Penford, a further 33 percent increase in specialty industrial starch capacity by 1993.

However, the big news in plant expansion this year has been ethanol.

Corn refiners are responding to the increased need for ethanol as part of the Clean Air Act strategy to improve air quality. In 1991, Cargill came into the ethanol economy, CPC International initiated a major expansion at its Pekin Energy joint venture project, Minnesota Corn Processors, a farmer-owned cooperative, began construction of Nebraska's first corn wet milling facility, primarily for ethanol production, and other ethanol refineries are on the drawing boards throughout the corn refining industry. While just a few years ago only a few corn wet millers were in the ethanol business, today most CRA member companies are in the alcohol fuel market, including our newest member, Roquette America.

Rising Corn Demand and Product Shipments

These advances produced another year of growing corn demand and growing shipments by CRA members. Corn usage in 1991 was up over three percent, and

Member company shipments increased 3.3%.

member company shipments increased 3.3 percent, despite the recession's effects on important consumer industries.

Wet milling industry exports grew by over 15 percent in 1991. Corn refining, which began in the United States and has reached its most extensive level of development here, is more and more an international industry.

U.S. companies have expanded into world markets, winning increased acceptance for corn products. In other nations, corn refining technology is increasingly being put to work, often with joint ventures or other links to U.S. companies. Most of CRA's member firms are major factors in world agricultural markets, and all of the U.S. industry has a deep interest in developing new international roles for corn products.

Trade Challenges

Corn refiners faced other challenges besides the recession in 1991.

As corn refining has been internationalized, trade issues have become more critical to the industry's success. For example, the long struggle over agricultural trade policy in the Uruguay round of GATT negotiations presents Jekyll-and-Hyde possibilities.

A pact that compromises too much and allows too many nations to continue trade abuses could seriously damage the U.S. corn industry.

The European Community's "rebalancing" proposal represents the kind of worst-case scenario that we oppose. Rebalancing would allow the E.C. to rearrange its trade restrictions to limit imports of products like corn gluten feed in exchange for liberalization in other areas. Corn refiners reject such a zero-sum proposal, especially one which would have such a dramatic effect on U.S. corn processing and production. Rebalancing would arbitrarily raise production costs for products like ethanol and HFCS while adding nothing to the export possibilities of other segments of U.S. agriculture.

Conversely, a successful negotiation that strips market-distorting policies out of the world economy could open the door for corn refiners to expand into major markets.

Among the benefits that could flow from such a pact would be the increased use of GATT and the U.N. Codex Alimentarius Commission as vehicles for harmonizing international food standards and resolving technical barriers to trade. Such negotiations could produce widely accepted specifications that would cut commercial red tape and transaction expenses and assure safer, more consistent products to consumers around the world.

Last year's corn gluten feed dispute represents a classic example of the kind of problem that could be prevented. European customs officials, applying a novel technology to the testing of feed ingredients, suddenly ruled that U.S. corn gluten feed did not meet E.C. specifications and began placing prohibitive customs duties on the product.

After months of meetings and a major effort to improve E.C. officials' understanding of the nature of corn refining and refined feed products, U.S. and E.C. officials recognized that U.S.-produced corn gluten feed was acceptable under their import classifications. However, the cost of the misunderstanding in time and money was significant not only for corn refiners, but also for the industry's European customers.

Corn refining would also benefit from higher profile GATT reforms—such as opening restricted markets like the European Community to corn sweeteners or Asian markets to modified starches. While any GATT agreement will require many adjustments, some positive and some negative, the U.S. corn refining industry is

positioned to be one of the winners in a truly fair global trading environment.

The same is true of the pros and cons of a North American Free Trade Agreement. If political leaders can achieve the necessary reforms, corn refiners, with their efficiency as sweetener producers and expertise in starch technology, can look forward to even more growth potential in the decades ahead.

Domestic Concerns

Domestic policies can also encourage or thwart the growth of industries like corn refining.

While harmonizing international food standards would benefit corn refiners, the current U.S. tendency to balkanize regulations represents a threat to industry. In areas such as food labeling, food safety and right-to-know regulations, state legislation may force the food industry to cater to 50 separate sets of rules. As on the international level, both U.S. consumers and industries are better off with a single, well-enforced regulatory system that provides the same protection for all Americans.

Looking Forward

While corn refiners are proud of their achievements in 1991, what's most important is that we look forward to even better growth, as we realize some of the gains initiated last year.

Since 1980, the corn wet milling industry has achieved an average compound growth rate of about 6.5 percent annually. Maintaining that rate would mean that our industry will use nearly two billion bushels of corn each year by 2001. That is our goal.

Achieving that goal will require a series of events—some within the control of our industry, and some not. We can be sure that corn wet millers will continue the research, development and productive investment which will support this goal. We can be sure that American's corn producers will be ready with adequate, quality, raw materials. We can be less sure of the course of political events which may promote or retard this growth. However, our industry is committed to do all it can to take wet milling to the two-billion-bushel mark and beyond in the next decade.

Shipments of Products of the Corn Refining Industry—1991

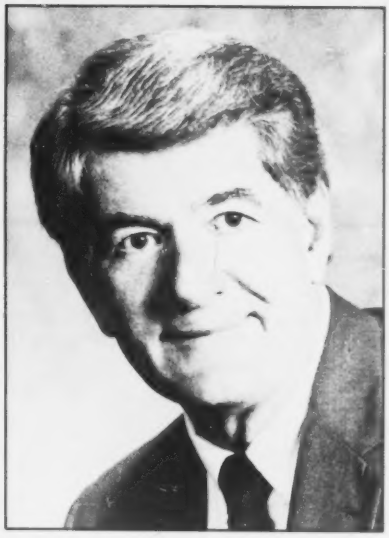
Starch Products	
(Includes corn starch, modified starch and dextrins)	5,149,754,000
Refinery Products	
(Includes glucose syrup, high fructose corn syrup, dextrose, corn syrup solids, maltodextrins)	23,752,992,000
High fructose corn syrup—42%	7,086,236,000
High fructose corn syrup—55% +	9,124,011,000
Total HFCS	16,210,247,000
Total—Domestic Basic Products	28,902,745,000
Total—Export Basic Products	698,864,000
Corn oil (crude and refined)	1,097,760,000
Corn gluten feed and corn oil meal	9,329,472,000
Corn gluten meal	1,872,666,000
Steepwater	386,152,000
TOTAL SHIPMENTS	42,287,659,000

Compiled for the Corn Refiners Association, Inc., by Ernst & Young. Statistics represent shipments by members of the association. Shipments are in pounds, commercial weights.

Member Company Products

	ADM Corn Processing	American Maize-Products Company	Cargill, Incorporated	CPC International Inc.	Minnesota Corn Processors	National Starch and Chemical Company	Penford Products Company	Roquette America, Inc.	A.E. Staley Manufacturing Company
Starch Products									
Unmodified, food	●	●	●	●	●	●		●	●
Unmodified, industrial	●	●	●	●	●	●	●	●	●
Modified, food		●	●			●	●	●	●
Modified, industrial	●	●	●	●		●	●	●	●
Dextrins	●	●				●		●	●
Cyclodextrins		●						●	
Refinery Products									
Glucose syrups	●	●	●	●	●		●	●	●
Maltodextrins		●					●	●	●
Dextrose monohydrate	●			●				●	●
Dextrose anhydrous				●				●	
HFCS-42	●	●	●	●				●	●
HFCS-55	●	●	●	●				●	●
Crystalline fructose	●								●
Co-Products									
Crude oil	●		●						●
Refined oil	●		●	●					●
Corn gluten feed	●	●	●	●	●	●	●	●	●
Corn gluten meal	●	●	●	●	●	●	●	●	●
Corn germ or corn germ meal	●	●	●	●	●	●	●	●	●
Steepwater (CFCE)		●	●	●	●	●	●	●	●
Carbon dioxide	●				●				●
Other									
Ethanol, fuel/industrial	●		●	●	●			●	●
Ethanol, beverage	●								
Fermentation and other chemicals	●		●					●	

Product lists are accurate as of publication date but may change with time.



What Agriculture Needs In the Next Ten Years

by Edward R. Madigan
Secretary of Agriculture

What farmers need in the next ten years can be summed up fairly easily. They need stronger domestic markets and a better shot at export markets.

Getting that done is not so easy. But we can do it.

The first priority for farmers is to operate in a sound, expanding U.S. economy with a low rate of inflation. That's better than any government program.

A bustling economy that creates paychecks builds demand for farm products. Paychecks that steadily gain buying power over time are the underpinning of the kind of strong economy with low inflation that farmers need.

Some people say that farmers like inflation. Land prices go up. And farmers can pay off their debts with cheaper dollars. But I didn't find farmers in my former congressional district in Illinois talking that way about inflation in the late 1970s and early 1980s.

Inflation forced farmers' costs sky high. Farmers couldn't keep up. Their debts mounted rapidly in 1975-80, and their interest charges soared out of sight! And farm net income sagged.

Farmers sell three-fourths of their farm products into the domestic market. Much of that demand is built in. People are going to continue eating. Each baby adds a growing, healthy appetite to the demand for farm products. However, our population isn't growing as fast as it once did.

Population experts think that in the next 30 years we might add about 44 million people to the U.S. population, more than a third fewer than in the last 30 years.

It surprises most people to learn that farmers have fed the 71 million larger population in the last 30 years by harvesting less land. In 1960 farmers harvested 255 million acres for the U.S. domestic market. In 1990 it took only 216 million acres—15 percent fewer.

How do farmers do it? By increasing productivity and better efficiency, mainly. Yields are higher and farm output per hour increased more than three times faster than in U.S. businesses.

The first priority for farmers is a sound. . .U.S. economy with a low rate of inflation.

To maintain a strong domestic farm market in the U.S. in the next decade and beyond, we need to develop higher-value industrial uses for farm and forest products. We need that to help offset the decline in the rate of population growth and to absorb increased agricultural productivity.

We are using more corn per capita domestically. But we need to do better for corn and other farm products. Corn growers have benefitted from a steady increase in the use of corn for cereals and starches—and the big increase in the use of high fructose corn syrup and corn for producing ethanol.

We have put new funds in next year's USDA budget to increase research in industrial uses for farm products. We will be pushing ethanol research, particularly methods of reducing ethanol production costs to make it an economically competitive fuel. Already the ethanol industry is using close to 400 million bushels of corn per year in ethanol production. The potential is much greater.

The implementation of the Clean Air Act will make ethanol and ethanol-based fuels an increasingly important renewable resource fuel. We have an opportunity to increase the domestic outlet for corn, help the country meet its environmental goals, reduce our petroleum imports, improve our national security, strengthen our balance of trade, and create important new markets for corn and other farm products.

New uses aren't limited to ethanol. One company has plans underway to convert biodegradable plastics from agricultural crops. A plant in McAllen, Texas, plans to make newsprint from kenaf, an agricultural crop. Mobil Oil is making a refrigerant and lubricant from rapeseed oil and is marketing it commercially. Austria, trying to combat pollution, has plans to manufacture diesel fuel made from soybean oil.

New uses for traditional farm crops not only mean added income for agriculture, but can stimulate the vitality of our rural communities. New uses will put idle land to work and will strengthen farm prices. This will increase demand for farm production items supplied through rural businesses. New uses will also create more jobs in rural marketing and processing industries. That increases the tax base in rural areas and strengthens rural institutions.

New uses for traditional farm crops...can stimulate the vitality of our rural communities.

Concern for the environment will become more important as farmers contribute to good living conditions while staying economically competitive. We are increasing our USDA budget in important areas to help with that. We are boosting research on biotechnology that will build greater disease and pest resistance into our plants and animals. It will lead to plants that will be more resistant to drought, summer heat, and frosts, and plants that will be more receptive to saline soils. It will give us the ability to fight insects with hormones and fight livestock diseases with bioengineered vaccines, instead of harsh chemicals.

Overall, these advancements will cut farm costs per unit of production.

Advancements in biotechnology will also help food processing as we create new foods, more nutritious foods, foods with longer shelf life, higher quality foods, and higher value foods.

Other countries around the world will be doing the same. We must lead the way or lose markets. We can't defend our markets or prosper by standing still and hanging onto higher cost, less efficient methods of farm production and processing. Others will pass us by.

American farmers sell one-fourth of their products into competitive export markets. This has been a growing market, but we have lost ground. In 1960 we exported the production from 64 million U.S. acres. By 1980 that had reached 137 million acres—a remarkable 114 percent increase. Unfortunately, that had declined to 81 million acres by 1985.

We know what it means to lose export markets. We learned a very costly lesson in 1981-85. Our farm export tonnage and dollar value shrank more than one-fourth.

Our domestic demand held up—in fact, actually set records throughout 1980-85. But our loss of farm export markets plunged American agriculture into a steep recession. It was very painful. Could there be any clearer evidence that the severe 1980-85 farm recession was a farm-export recession.

During that time, the European Community decreased its wheat and feed grain imports by nearly 18 million tons and boosted its exports. U.S. exports of wheat and feed grains suffered losses of comparable size.

How did the E.C. do it? By boosting production, keeping out grain imports with restrictive border barriers, and spending large amounts of money to subsidize its farm exports in markets where we and other exporters were competing.

That's what the present GATT Uruguay Round negotiations are all about. It's why the U.S. is adamant that we get world-wide changes in trade rules that will prevent harm to U.S. farmers and U.S. agriculture—and to other countries as well.

GATT has been a hard fight for more than five years. We have "hung tough" because so much is at stake for American farmers. But not just that. So much is at stake for our entire economy, for other countries, and for economic growth in the world. The negotiations go beyond agriculture.

The GATT agreement will affect the vigor and growth of American businesses and the creation of jobs for the American workforce. That affects U.S. farmers in their primary market where they sell three-fourths of their farm products.

That is the agenda: Aggressive action to broaden and increase the demand for U.S. farm products here at home and abroad; better research to hone the competitive ability of U.S. agriculture and the quality of its products; increased profitability for American farmers; and cooperation among federal, state and local governments and local businesses and private groups and leaders to bring new life to rural communities.

Corn: Supply and Disappearance

	Supply				Disappearance						Ending Stocks		
					Domestic Use								
Year beginning September 1	Beginning stocks	Production	Imports	Total	Food, alcohol and industrial	Seed	Feed and residual	Total	Exports	Total disappearance	Govt. owned	Privately owned	Total
					Million bushels								
1981/82	1,392.1	8,118.7	0.6	9,511.3	714.0	19.4	4,244.5	4,977.9	1,996.8	6,974.7	280.1	2,256.5	2,536.6
1982/83	2,536.6	8,235.1	0.5	10,772.2	840.0	14.5	4,573.2	5,427.7	1,821.3	7,249.1	1,142.7	2,380.4	3,523.1
1983/84	3,523.1	4,174.3	1.7	7,699.1	911.0	19.1	3,876.3	4,806.4	1,886.4	6,692.8	201.5	804.8	1,006.3
1984/85	1,006.3	7,672.1	1.7	8,680.2	1,046.0	21.2	4,114.5	5,181.7	1,850.3	7,032.0	224.9	1,423.3	1,648.2
1985/86	1,648.2	8,875.5	9.9	10,533.6	1,133.0	19.5	4,114.2	5,266.7	1,227.3	6,494.1	545.7	3,493.8	4,039.5
1986/87	4,039.5	8,225.8	1.8	12,267.0	1,206.8	16.7	4,669.4	5,892.9	1,492.5	7,385.3	1,443.2	3,438.5	4,881.7
1987/88	4,881.7	7,131.3	3.4	12,016.4	1,226.0	17.2	4,797.7	6,040.9	1,716.4	7,757.3	835.0	3,424.1	4,259.1
1988/89	4,259.1	4,928.7	2.8	9,190.6	1,275.0	18.4	3,940.9	5,234.3	2,025.8	7,260.1	362.5	1,567.9	1,930.4
1989/90	1,930.4	7,525.5	1.9	9,457.8	1,337.0	18.9	4,389.2	5,745.1	2,368.2	8,113.4	233.0	1,111.5	1,344.5
1990/91[1]	1,344.5	7,934.0	3.4	9,281.9	1,348.0	19.3	4,668.7	6,036.0	1,724.6	7,760.7	371.1	1,150.1	1,521.2
1991/1992[2]	1,521.2	7,474.5	20.0	9,015.7	—— 1,400.0 ——			5,000.0	6,400.0	1,525.0	7,925.0	25.0	1,065.7	1,090.7

[1]Preliminary
[2]Projected
Source: USDA

Regional free trade would result in the world's largest sweetener market.

NAFTA: Potential Markets To Be Realized

by Thomas C. Earley, Vice President
Abel, Daft & Earley

As the Uruguay Round of multilateral trade talks lurches toward an uncertain conclusion in 1992, an equally important set of negotiations is well underway on a proposed North American Free Trade Agreement. Known as NAFTA in the United States and Canada, and as TLC in Mexico, this pact among the three countries would build on the U.S.-Canadian Free Trade Agreement (FTA) which took effect January 1, 1989. That agreement calls for phasing out tariffs between the two countries over a ten-year period, and also addresses a variety of non-tariff barriers.

A North American FTA could have some positive long-term impacts on U.S. corn refiners, in contrast to the likely effects of the multilateral negotiations under the auspices of the General Agreement on Tariffs and Trade (GATT). The latter would probably result in lower U.S. sugar and sweetener prices, and higher net corn costs. USDA projections imply that U.S. corn prices would be 10 to 20 cents per bushel higher with a GATT agreement than without one. Moreover, it is also likely that returns from sale of byproducts would decline, or at best stay the same. Corn oil prices could be weakened by reductions in the U.S. tariff on soybean oil, and gluten feed prices would decline due to reduced E.C. grain price supports. Gluten meal prices would rise with U.S. soybean meal prices. The total effect of higher corn prices and lower by-product credits would probably be to raise net starch costs for corn sweeteners from the normal three cents up to almost four cents per pound, dry basis. This would not be a major change, but it could be an uncomfortable one in an environment where U.S. sugar price supports are declining and low calorie sweeteners are becoming more competitive.

A GATT agreement may or may not become a reality. As one looks ahead early in 1992, it seems improbable that the United States and the European Community will resolve their differences over agriculture. However, the mood surrounding the current NAFTA negotiations is more upbeat, and it would be very surprising if they are not brought to a successful conclusion this year or next. While the immediate effects of NAFTA on corn refiners are apt to be small, they could be quite large over the longer term.

Freer trade in sweeteners in North America is an intriguing concept for a number of reasons. There is already a considerable amount of cross ownership of sweetener production facilities, and there are some obvious efficiency gains that would accrue in the distribution system. But first and foremost, regional free trade would result in the world's largest sweetener market by any measure—low-calorie, sugar, or total. In the case of sugar, North America would barely edge out the European Community and India. If one includes all sweeteners, there is simply no contest due to the important role played by HFCS and aspartame in Canada and the United States.

The accompanying table presents a summary of North American caloric sweetener markets in 1990. The corn sweetener figures are on a dry basis. Total consumption of raw sugar, HFCS, glucose, and dextrose in the three countries was just over 22 million metric tons (mmt.) and is growing. Anyone in the sweetener business cannot help but be intrigued by a market of that size.

All three countries are net importers. In 1990 they imported over five mmt. of sugar and corn sweeteners and exported less than one mmt. Of the exports, two-thirds were within the region. Imports in 1990 were unusually high in both Mexico

and the United States, so a more typical level for the three countries would be in the 3.5 to 4.0 mmt. range.

Caloric sweetener production in 1990 exceeded 18 million tons, with 80 percent of it occurring in the United States. Taking the three countries as a whole, output was equally divided between sugar and corn sweeteners. Production in 1991 easily exceeded 19 mmt., with most of the gains being in the sugar sector.

As the table suggests, HFCS has only a tiny share of the Mexican caloric sweetener market, and glucose and dextrose are not much better off. The reasons for this are simple. First, the Mexican government has kept sugar prices too low and corn prices too high for the economics to work out favorably, so there has been no incentive to invest in production facilities. And with trade tightly controlled by an import licensing system, there has not been an assured supply of suitable corn to use as the raw material. Second, and equally important, the logistical support system for a liquid sweetener market just does not exist yet for the nation as a whole. Rail shipping costs in Mexico are significantly higher than in the United States, and service is less reliable.

Yet the prospects are enticing. Mexico has very high per capita sugar consumption—105 pounds compared to only 65 pounds in the United States. About a third of that is in the form of soft drinks, which serve as a source of both energy and potable water. In the United States, HFCS has replaced most of the sugar in soft drinks for economic reasons. In Mexico, most soft-drink bottlers are not equipped to receive either liquid sugar or HFCS. Instead they purchase refined sugar and convert it into liquid sugar in their plants. But the potential for HFCS to penetrate this market in coming years is clearly there if economic incentives and the logistical system evolve to where they will permit it.

In the absence of an agreement that opens up trade in sugar, corn, and corn sweeteners, there will be only a limited role for HFCS in Mexico. The current tariff is a significant barrier to imports, and the lack of a cheap and reliable corn supply would continue to preclude any major investment in domestic production of HFCS. Moreover, without the incentive of an available supply of low cost liquid sweetener, traders and users are unlikely to invest in the necessary logistical and handling systems.

With a comprehensive NAFTA, one could be looking at a quite different scenario. If the tariff on HFCS is phased out over five years, it would be gone by 2000. With a ten-year phase out, it would be down to an inconsequential three percent by 2000. This would make U.S.-produced HFCS competitive in Mexico.

Perhaps the biggest change that could occur as a result of a North American FTA is that the Mexican government will eventually discover that it is in the nation's interest to develop its own corn sweetener industry. Like Canada and the United States, Mexico will never be self-sufficient in sugar.

North American Caloric Sweetener Markets in 1990

	Production	Imports	Exports	Consumption
	in thousands of metric tons			
Canada				
Sugar	145	950	40	1,040
HFCS	205	40	140	100
Glucose & Dextrose	150	50	20	180
U.S.				
Sugar	5,740	2,510	560	7,860
HFCS	5,610	140	70	5,620
Glucose & Dextrose	2,900	10	50	2,860
Mexico				
Sugar	3,395	1,565	5	4,490
HFCS	—	10	—	10
Glucose & Dextrose	200	—	—	200
Total	18,345	5,275	885	22,360

Source: Abel, Daft & Earley

While it has the potential to be a relatively low-cost producer, the nation's land resources are limited, and the rapid rate of population growth will make it very difficult for production to catch up with demand.

Because HFCS and other corn sweeteners can be produced at low cost compared to sugar, Mexico should be encouraging development of a domestic corn refining industry, even if it will be necessary to import the corn. The diverse products that corn refiners manufacture will all be needed as Mexico's industries evolve. And the technology is one that any developing economy would benefit from.

It is, of course, possible that agriculture and food will somehow be excluded from NAFTA coverage. But the outcome is clearly one in which U.S. corn refiners have a stake, whether through creation of an export market, or through participation in development of Mexico's own corn refining industry.

U.S. Per Capita Sweetener Consumption

Year	Refined sugar	Corn sweeteners			Honey and edible syrups	Total caloric sweeteners
		HFCS	Glucose	Dextrose	Total		
	Pounds, dry basis						
1985	62.7	44.9	18.1	4.2	67.2	1.4	131.3
1986	60.0	45.6	18.3	4.2	68.1	1.4	129.5
1987	62.4	47.2	18.5	4.3	70.0	1.4	133.8
1988	62.1	48.6	18.7	4.3	71.6	1.4	135.1
1989	62.8	48.7	19.2	4.3	72.2	1.4	136.4
1990	64.5	49.1	19.6	4.5	73.2	1.4	139.1
1991*	64.5	49.6	19.8	4.5	73.9	1.4	139.8
1992**	64.5	50.0	20.0	4.6	74.6	1.4	140.5

*Preliminary
**Forecast
Source: USDA—Economic Research Service

HFCS: The Outlook In A Changing World Scene

by Landell Mills Commodities Studies

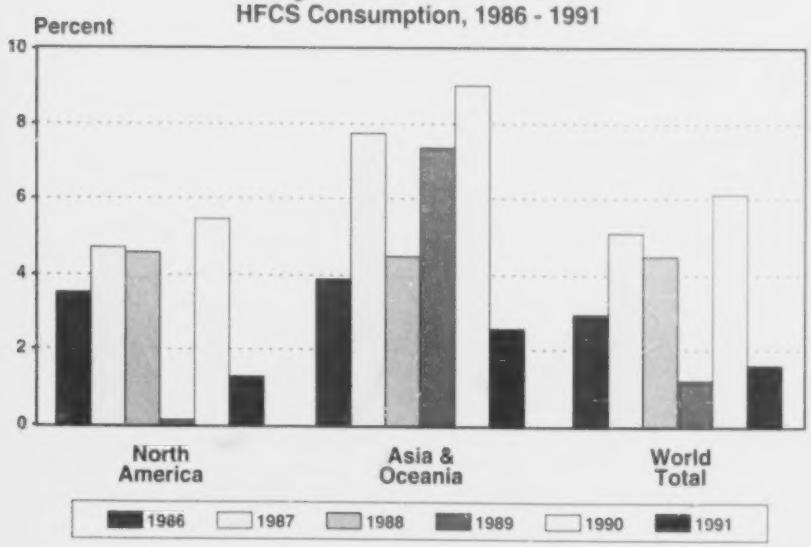
1990 was a good year for the HFCS industry. [We will concentrate in this review on prospects for HFCS, the biggest and most diverse of the corn sweetener sectors.] Sales of HFCS moved ahead in all of its major markets, and its share of the nutritive sweetener market increased in every major country, apart from Argentina.

Globally, 1990 saw HFCS consumption rise by 6.1 percent to total 7.7 million metric tons[1], dry weight. With sugar demand stagnant in the rest of the world, HFCS found it relatively easy to boost its share of the global market for sugar and HFCS combined above 7 percent for the first time. The industry's rise in sales of more than 6 percent in 1990 was in stark contrast to the second half of the 1980s, when HFCS consumption grew at an average annual rate of 3.4 percent (see Diagram 1).

It is unlikely that the strong showing made in 1990 signals an acceleration in HFCS sales in the 1990s. Indeed, preliminary estimates for 1991 suggest that HFCS sales rose to 7.8 million tons, dry basis, only 1.1 percent above consumption in 1990. The particularly robust advances in corn sweetener sales in 1990 were the result of an unusual set of circumstances, including relatively high world sugar prices, particularly strong growth in Japan as a result of an unusually warm summer, and rapid increases in some developing markets.

Few of the elements which helped the HFCS sector in 1990 are likely to be present over the next few years. With world sugar prices at a much lower level and recessions, or at least much slower economic growth, in HFCS's most important markets, North America and Japan, the prospects for rapid advances over the next few years are slim.

Diagram 1: Annual Growth in HFCS Consumption, 1986 - 1991



In the following paragraphs, the market conditions for HFCS in several regions are reviewed, with an eye towards identifying where there might be potential for substantial progress, given favorable relative price conditions. Because 1990 is the latest year for which there are final statistics, we have concentrated our discussions on that year; however, we have commented on preliminary estimates for 1991 where available.

Trends in North America

North America continues to dominate the world picture, accounting for almost 75 percent of global HFCS consumption (as against only one third of world glucose and dextrose output). On the production side, the official US statistics for 1990 reveal an increase of well over 5 percent in domestic HFCS output over

its level in 1989, belying the pessimism engendered by the growth in the share of diet soft drinks in the US market.

However, some of this increase constituted a replenishment of users' stocks after they were drawn down in 1989, while another important factor was a sharp reduction in net imports from Canada. In contrast to 1990, preliminary estimates for 1991 suggest that output increased over 1990's level by less than 2 percent, to 5.7 million tons, dry basis.

The cross-border trade that occurs between the US and Canada is one of the major features of the broader North American picture. Until recently, the general trend has been for flows to run from Canada to the US, with Canadian shipments to the US peaking at roughly 200,000 tons, dry weight.

Canadian sugar prices are linked to world market values; therefore, the revival of world prices after 1985 helped to boost Canadian HFCS sales. By 1990, US shipments to Canada exceeded 80,000 tons and the export surplus of Canada had fallen below 50,000 tons, a quarter of the level just four years earlier.

The two other growing regions for HFCS sales are Latin America and Africa.

Trends in Asia

The Asian region made an important contribution to the global 1990 and 1991 HFCS performances. Sales in the Japanese HFCS industry, although growing more slowly than its North American counterpart, strengthened in 1990, largely as a result of a very warm summer, which boosted sales of soft drinks.

Compared with growth of 3 percent in 1989, the increase in HFCS sales was well over 5 percent in 1990. With the resumption of more typical summer temperatures in Japan in 1991 came a more normal rate of increase in consumption, with HFCS sales rising by 1 percent over the level in 1990.

Elsewhere in Asia, Taiwan is likely to be the next 100,000 ton-plus HFCS producer. High domestic sugar prices, an expanding soft drink sector and government support for maize imports were the spurs to the rapid development of HFCS sectors. In 1990, HFCS production in Taiwan exceeded 67,000 tons, dry basis, a gain of over 30 percent on 1989. Preliminary figures suggest that output rose substantially in 1991, as well.

Trends in Latin America and Africa

The two other growing regions for HFCS sales are Latin America and Africa. HFCS sales in the two regions combined increased by more than 17 percent between 1989 and 1990. The largest corn sweetener industry in the two regions is found in Argentina, where HFCS production quotas were in place until 1991, but where the sector is now entirely unregulated.

However, when quotas were in place, it was not the supply side that was constraining demand, but the other way around. 1987 was the last year in which the economy was performing well enough to generate demand for the entire production quota, which stood at 82,495 tons of fructose content (equivalent to roughly 170,000 tons, dry basis). The quota rose by approximately 10 percent in 1988, but total sales actually fell back. The recession which took hold in 1989 pushed sales down further, to a greater degree than the decrease that was imposed upon the 1989 quota.

The first half of 1990 saw a continuation of the recession, but the situation started to improve in the second half of the year. For 1990 as whole, output is estimated to have recovered to the levels prevailing four years earlier. This revival has continued into 1991 with sales to the soft drink sector reported to have been very good.

Trends in Europe

The only region which singularly failed to participate in the acceleration in HFCS output was Europe. EC production remains capped by quotas, which are set at 291,115 tons, dry basis, within the framework of the Sugar Regime of the Common Agricultural Policy. Elsewhere, the disintegration of East European economies has taken its toll on HFCS producers. Two projects that were supposed to have been commissioned by now, in Bulgaria and Kirghizia (in the old USSR), are still some way from start-up.

Prospects for the 1990s

The HFCS industry began the 1990s with relatively rapid growth in sales. A much more modest increase in 1991 showed how unusual was 1990's rise in demand and highlighted the sensitivity of prospects for HFCS to world sugar prices. Relative costs of sugar and HFCS play a very important role in determining the location of wet milling plants.

It comes as little surprise to discover that the current rapid slowdown in HFCS production worldwide has coincided with a period of depressed world sugar prices. Many of the potential producers of HFCS are importers of sugar; therefore they make an explicit trade-off between the costs of importing more sugar from the world market and the likely costs of production of HFCS. When world prices of sugar do eventually manage to sustain a recovery, the viability of new HFCS plants will look much more attractive, and a new wave of investment can be expected to materialize.

[1]All measures in this article are expressed in metric ton of 2,204.62 pounds.

World Corn Supply and Disappearance

	1990/91	1991/92
Exports		
Argentina	3.7	4.6
South Africa	0.8	0.8
Thailand	1.2	0.9
China	6.6	7.5
United States	44.5	39.0
Others	0.6	3.2
TOTAL	57.2	56.0
Imports		
Mexico	1.9	1.0
European Community-12	3.7	2.0
C.I.S.	10.1	9.0
Japan	16.0	16.2
Eastern Europe	1.4	0.3
China	0.0	0.0
Taiwan	5.3	5.5
Republic of Korea	5.6	5.5
Others	13.3	16.6
TOTAL	57.2	56.0
Production		
Brazil	23.5	26.0
Mexico	14.1	14.5
Argentina	7.6	8.0
South Africa	8.2	6.0
Thailand	3.8	3.7
European Community-12	21.6	26.6
C.I.S.	9.8	11.0
Eastern Europe	21.1	30.9
China	96.8	95.0
United States	201.5	189.9
Others	70.9	69.7
TOTAL	478.9	481.3
Utilization		
European Community-12	26.9	29.0
C.I.S.	17.1	20.0
Japan	16.3	16.3
China	80.4	82.0
United States	153.3	162.6
Others	173.8	176.8
TOTAL	467.8	486.6
Ending Stocks		
Foreign	43.6	49.2
United States	38.6	27.7
TOTAL	82.3	76.9

Source: USDA • Based on October/September year in millions of metric tons. • 1991/92 represents a forecast total.

A bushel of corn, converted into oil, CGF and modified starches, produced export earnings of over $12.

Industry Exports: Contributing to a Positive Trade Picture

Over the last ten years, the U.S. corn refining industry has begun a quiet transformation, developing a stronger focus on export markets and potential. In the process, the refining industry's contribution to a positive U.S. trade balance in general and the corn economy in particular has grown.

In 1982, only corn gluten feed played a significant export role; other industry products went almost entirely to domestic markets. Since then, refining industry exports have grown dramatically, far outstripping industry growth as a whole.

This rise is especially important because export potential is increasingly focused on value-added products. USDA estimates show limited opportunities to increase bulk commodity exports but a very positive future for processed agricultural products. While refiners' exports have established exciting growth rates in the last decade, the potential for starch, sweetener and byproduct exports is far from being realized. There is still a lot of room to expand, given fair marketing conditions.

A simple comparison suggests the importance of value-added corn product exports to the U.S. economy: In 1990, a bushel of corn shipped FOB out of U.S. gulf ports brought a price of $2.70. The same bushel, converted into crude corn oil, corn gluten feed, corn gluten meal, and modified starches, produced export earnings of over $12.00.

That price differential translated into jobs created, taxes paid, supplies and equipment purchased, and capital investment made, all in America. It also improved the ailing U.S. balance of trade.

In fact, corn refiners contribute positively to the U.S. trade balance in two different ways. The obvious contribution is through greater, and more valuable, exports of corn products—exports worth $1.3 billion in 1991. The second, less obvious contribution is through the increased domestic use of corn products that replace imported goods.

Historically, the most important of these substitutions has been sugar. As world residual sugar prices fluctuate, the year-to-year benefit from corn sweeteners varies. In 1990, the most recent year for which full statistics are available, the United States used 6.12 million short tons of high fructose corn syrup (dry weight). In the absence of HFCS, it would have cost over $2 billion to import a similar quantity of sugar.

Other corn products have begun to play a similar role. While ethanol has been adopted primarily because of its environmental advantages, its blending with gasoline also reduces U.S. dependence on foreign oil by over 900 million gallons annually, worth over $500 million.

More recently, the refining industry's move into lysine and citric acid production is reducing the need to import these essential food, chemical and feed ingredients from areas like the Pacific Rim. The growing diversity of corn refining applications promises to increase this hidden contribution to the trade picture even more.

The picture is also changing for direct exports. Since 1982, the refining industry's use of corn has increased by about 75 percent, while exports of refined corn products have grown by 125 percent.

Where is the U.S. sending its refined corn products?

Feed Products Corn gluten feed has posted the lowest growth rate of any co-product in the last ten years, reflecting the fact that much of its export development occurred before 1982. CGF continues to go to the European Community and will

remain concentrated in that market as long as the E.C.'s artificially high grain prices and tariffs bar the market to corn and other feed ingredients. In fact, the E.C. trade in CGF represents only a modest compensation for historical U.S. corn sales that have been lost in Europe.

Corn gluten meal, on the other hand, is exported primarily to the Pacific Rim nations, where it is in demand in the poultry industries developing to meet the protein demands of larger, more affluent populations.

Corn Oil is shipped predominantly to the Middle East, which took over 120,000 metric tons worth almost $82 million in 1991. However, significant amounts of oil also flow to the European Community, to Pacific Rim nations, to Mexico, India, and Africa. Shipments to all four second-tier markets total just over 100,000 tons. Despite the disruption of Middle Eastern markets by last year's gulf war, corn oil exports have grown by more than 150 percent.

Starches find their primary market in Canada, which took 15,000 metric tons of common corn starch. The next most important markets are the E.C. (10,000 tons) and the Pacific Rim (7,500 tons). Despite promising potential in other regions, Canada also takes nearly 90%—48,000 tons—of U.S. modified starch exports.

Export growth in starches hits the extremes. Foreign sales of common corn starch are up just 82 percent from 1982 to 1991, the lowest level of any of the refined corn products. However, modified starch shipments abroad racked up the highest growth level, increasing 20 times over in the same period.

Modified starches, in particular, could benefit from trade reforms that would open more markets. Expanding industries like papermaking in the Far East and textiles in south east Asia need not only more starches, but better starches to maintain their growth and improve product quality.

Corn sweeteners have also posted major export gains, growing by almost 550 percent during the decade. Again, Canada is the primary market, taking $62 million worth of sweeteners last year, or 77 percent of U.S. exports. Like starches, sweeteners hold the promise of even greater export growth if world trade reforms were to open major markets that are now restricted.

In all, corn refiners ship 27 percent of the billion-plus bushels of corn they process to foreign markets. Combined with the positive offsets refiners provide against oil, sugar and other imports, corn refining contributes $4 billion annually to the U.S. balance of trade.

Exports of Products From Corn

Product	1991	Units
Corn meal	193,516,629	Kilograms
Corn starch	50,317,280	Kilograms
Starch NESOI*	14,175,196	Kilograms
Corn oil, crude	180,140,007	Kilograms
Corn oil, once refined	25,929,659	Kilograms
Corn oil, fully refined	29,370,249	Kilograms
Glucose in solid form and glucose syrup with below 20% fructose	79,735,404	Kilograms
Glucose syrup with 20-50% fructose	9,299,092	Kilograms
Chemically pure fructose	9,040,091	Kilograms
Fructose syrup with 50% + fructose	100,206,200	Kilograms
Fructose solids with 50 + fructose	9,494,486	Kilograms
Bran of corn	91,768	Metric tons
Corn gluten feed	5,543,492	Metric tons
Corn gluten meal	514,412	Metric tons
Other residues of starch manufacturing	297,652	Metric tons
Corn oilcake	533,266,736	Kilograms
Dextrins and other modified starches	55,248,481	Kilograms

*Not Elsewhere Specified or Included
Source: U.S. Department of Commerce

Refiners' Organizations Around the World

American corn refiners are not the world's only processors with a trade association. The Korea Corn Processing Industry Association, the Japan Corn Starch Association, the All-India Starch Manufacturers Association, and the European Cereal Starch Association comprise the leading overseas associations.

Each association has its own style and expertise: Compare with CRA, for example, the following description of the European Cereal Starch Association, by Annette Jung, AAC secretary general:

The AAC—Association des Amidonneries Cereales de la C.E. (European Cereal Starch Association) represents the cereal starch producers in the European Community. AAC member companies are: Cerestar/Ferruzzi, Roquette with SPAD and LAISA, CST with Amylum, Biamyl, ZBB, Tunnel, Campo Ebro, Cargill, National Starch, ABR, Emsland, Crespel & Deiters, Kroner, Jackering, Ogilvie, Latenstein, Pfeifer & Langen, Staper, Doitteau Emuldo, Seda and Copam. They have production sites in Belgium, Denmark, France, Germany, Greece, Italy, the Netherlands, Portugal, Spain and the United Kingdom.

AAC, created in 1988, was the result of a merger between the European Wheat Starch Association and the European Maize Starch Association. The founding associations were created with the beginning of the European Community in the late 1950s.

AAC's objectives are defined by the General Assembly of all members, meeting at least once a year. Its Executive Committee, composed of seven leading industrialists, directs the Association's political activities. Working groups ensure that the best expert knowledge is available for dealing with specific topics.

AAC president is Mr. J. Neirynck, general manager, Amylum. Mr. S. Kluzer, managing director, Cerestar, and Mr. W. N. M. van der Ham, managing director, Latenstein, are vice presidents. The Association's secretary general, Ms. A. Jung, is responsible for the AAC office in Brussels.

AAC studies and proposes solutions to economic, legal, political and technical questions concerning the cereal starch industry on an European level. It collects and disseminates information and represents the industry before the E.C. institutions and international organizations.

CRA: The Association Expands Its Role

The Corn Refiners Association, Inc., one of the oldest U.S. food trade associations, stands as an important part of the refining industry story. In its 80th year, CRA's work continues to grow, with activities in three major areas: government representation, information and promotion, and research and technological support.

In government representation, CRA provides a corn refining industry voice before Congress, the federal regulatory agencies, and, increasingly, on the state level. Representation is a two-way street, in which the Association keeps member companies informed about emerging issues while it educates and informs government decision-makers on the ways in which policies will affect the corn refining industry and the corn economy.

Often in concert with key agricultural groups such as the National Corn Growers Association, the U.S. Feed Grains Council and the Renewable Fuels Association, CRA works on issues as varied as maintaining viable farm programs, encouraging value-added corn product exports, finding funds for food safety research, and promoting new uses for corn. CRA also presents industry views before federal agencies covering food, environmental, transportation, and safety and health regulations.

CRA is a primary information source about the corn economy in general and the corn refining industry and its products in particular. CRA staff provide up-to-date information for journalists, business analysts, academics, and the general public, answering "corn questions" that range from basic to exotic. In addition, CRA produces a variety of publications, including the **Corn Annual**, aimed at providing ready access to information on the products and processes of the corn refining industry and current statistical information.

In the technical arena, CRA supports scientific research and education both through fellowships at major universities and outstanding research awards at professional conferences. Association committees also collaborate to develop standardized test methods for corn processing and corn products. The CRA provides these at cost to the general public. Finally, CRA sponsors biennial scientific conferences for the refining industry and related industry representatives to provide a forum for improving technological understanding.

Today the refining industry earns nearly one of every five dollars of sales in export markets that include Europe, the Middle East, Asia and the rest of North America. Responding to this growth, the Association has become increasingly involved in international issues. In trade policy, CRA's activities aim at maintaining and creating free markets in agricultural goods. In areas of international harmonization, CRA works to create practical and common standards and definitions for trade in agricultural products.

Since 1986, the U.S. has participated in global negotiations designed to break down barriers to free trade in agricultural products, industrial products and financial services. CRA and its member companies have served as an important resource for U.S. negotiators in identifying trade sectors which would expand if trade barriers were eliminated.

The Association has also been a leader in organizing opposition to European Community proposals to "rebalance" agricultural support policies. "Rebalancing"—a euphemism for creating new protectionist tariffs against exports such as corn gluten feed, soybeans and soybean products—has been a major E.C. goal in the GATT negotiations. However, strong opposition from the U.S. and the Cairns group of food exporting nations has stymied the E.C. rebalancing effort.

The construction of the Single European Market with 340 million consumers entails an increase in the number of decisions, which affect the starch industry, being taking by the E.C. institutions in Brussels. Moreover, close liaison with its associated members, the national starch associations, helps the AAC to play its full part in the complicated decision making procedures between the E.C. institutions and national governments.

Technical barriers can be as effective as tariffs or quotas in restricting trade. CRA has worked to eliminate both trade-distorting regulations that serve no legitimate health, safety or consumer protection function and trade-disruptive "reinterpretations" of product definitions. For example, the Association organized U.S. opposition to unilateral customs classification changes that threaten the $650 million U.S. corn gluten feed market in Europe. These actions, which violate long-standing GATT agreements, have been applied in a "hit and run" fashion to harass U.S. shippers and European feed users and are currently the subject of a major U.S.-E.C. trade dispute. The CRA has also led efforts to prevent arbitrary labeling regulations from being used to eliminate the growing export market for U.S.-produced crystalline fructose in Japan.

In international harmonization, the Association participates in deliberations of the Codex Alimentarius Commission. This group, a joint effort of the U.N.'s Food and Agricultural Organization and World Health Organization, works to unify product definitions, safety standards and use approvals for food and feed products in international trade. If an agreement is reached in the GATT talks, the Codex Commission will be called upon to resolve technical issues which could otherwise impede free agricultural trade. Codex committees are currently developing general standards for food additive and contaminant policy, sampling and analysis systems and procedures to be used by exporters and importers to assure compliance with Codex standards. Because of the complexity of these issues, government negotiators rely on assistance from U.S. industry and consumer groups. CRA has participated as a U.S. advisor to Codex committees since the 1960s.

Corn Production and Plant Locations

Over 700 million bushels per year:

- Illinois
- Iowa
- Minnesota
- Nebraska

250 to 700 million bushels:

- Indiana
- Michigan
- Ohio
- Wisconsin

100 to 250 million bushels:

- Colorado
- Kansas
- Kentucky
- Missouri
- South Dakota
- Texas

• CRA member company plant

Over 60 percent of the starch CRA members produce goes into paper and paper products.

Starch and Paper: Bonding for Better Products

While new applications for corn starch in degradable plastics, fat replacers, biotechnology feedstocks and microwavable applications have made headlines in recent years, paper and paper products remain the backbone of the starch market. Trade estimates suggest that over 60 percent of the common corn starch CRA members produce goes into paper and paper products and that the percentage is even higher for modified starches.

Last year, Americans used over 83 million tons of paper and paperboard products. Looked at from the papermaker's perspective, cellulose from wood is the single most important ingredient, but other chemicals, binders and coatings are essential to produce the array of paper products and qualities required.

Of these other ingredients, corn starch is a leader. In natural binders alone, corn starch has provided up to 84 percent of the American paper industry's needs. Since starch serves multiple purposes in papermaking, it is applied at various stages and in various forms.

At the wet end, or first stage in papermaking, a dilute slurry of fine wood fibers in water pours onto a moving wire screen. As the screen travels, water drains out of the slurry, forming a wet web of paper.

Corn starch can be added when the slurry is made and the wood fiber is being broken down or directly to the slurry on the wire screen. While common corn starch can be used, cationic corn starch is increasingly popular because its positively charged particles bond strongly to the negatively charged cellulose fibers. Paper strength was once thought to come from the physical interlocking of fibers. In fact, strength comes from chemical bonding like the cationic starch-fiber linkage.

As a result, using cationic corn starches in the wet end of papermaking produces stronger paper that will stand up better to high speed printing equipment or in packaging. This strength is even more important in recycled papers, since recycling breaks the wood fibers down and makes them weaker.

In addition to producing better quality paper, cationic starches allow papermakers to operate more efficiently and to reduce pollution from the process. The positive-negative bond helps retain added starch and other fillers in the paper, reducing waste in the drained water, while its contribution to paper strength allows manufacturers to use more mineral filler, reducing the demand for wood fiber.

The better dewatering that comes with cationic starches also allows papermakers to increase production rates and save on the energy needed to dry paper.

As paper comes off the wire screens, it passes through a series of heated rollers that remove more water and dry the paper. When nearly dry, it passes through the size press and the calendar stack, another series of rollers at which starch can be added.

Either the size press or the calendar stack can deposit a continuous film of starch onto the paper. Surface sizing improves the paper's finish, reduces scuffing or linting of the paper surface, improves paper strength and allows printers to produce higher quality work on more efficient high speed presses.

Surface sizing is especially important for writing paper, printing paper and certain grades of wrapping paper, and most of the starch in papermaking is used for sizing. While common corn starch has played a role in sizing for many years, changes in modern papermaking have prompted a move to specially modified starches like hydroxyethylated corn starch.

Last year's paper production translated into sales of over a billion pounds of starch for size press use alone.

Papermakers are increasingly shifting to alkaline papermaking, which produces a higher quality paper for less cost. In particular, alkaline papers last better over time because they don't contain damaging acids. However, the increased levels of mineral fillers, like calcium carbonate, in alkaline papers can reduce paper strength. Specialty corn starches, with their bonding qualities, compensate for the strength lost when more mineral fillers are used.

In 1991, papermakers produced over 11 million tons of uncoated free sheet paper and 7.3 million tons of coated paper. For corn refiners, that translated into sales of well over a billion pounds of corn starch for size press use alone.

The third major area of corn starch use in papermaking is in coated papers, like the slick papers used for magazine printing. Paper coating involves the application of a layer of pigment, adhesive and other materials to the surface of dry paper or paperboard.

Coatings provide whiteness, brightness, and gloss to the paper, create a smoother, more uniform surface and make the paper more opaque. The special qualities coatings provide are essential to different kinds of large scale and high speed printing.

A typical coated paper is composed of 70 percent raw paper stock, 25 percent pigment and five percent binder, of which the binder may be the most important ingredient.

Corn starches supply about 60 percent of the coating binder used in the United States because they meet so many of the key properties required in a binder: high pigment bonding strength, low cost, good color, strong film forming, adjustable viscosity, high plasticity, and good time, temperature and shear stability. This **Corn Annual**, for example, is printed on offset enamel paper which includes PENGLOSS® binder as a component of its coating.

While the binder's primary role is to make the pigment adhere to the raw stock, it also plays a major role in determining how the coating will flow across the paper, release water and set into a dry finish—all critical issues for quality control and efficiency in paper manufacturing. The amount of binder and its distribution in the coating layer also play a role in determining the appearance and printing qualities of the final coated sheet, such as how well the paper receives and holds ink on its surface. The second most-used binder, latex, offers some qualities that corn starch cannot but is significantly higher in cost. One of starch chemists' recent achievements is the development of a method of combining starch and latex into a unique product which delivers to the user the special binding advantages of latex with the added value benefits of corn starch.

The introduction of higher speed presses, the shift to better quality printing papers, and the use of more coated stock in the American paper industry has produced major changes in the patterns of starch use for paper.

Most evident is the shift from common corn starch to higher value modified starches. Last year, corn refiners shipped an estimated 1.5 billion pounds of modified starches to the paper industry for wet-end, coating and sizing uses—an increase of over 15 percent from the previous year. At the same time shipments of unmodified starches for paper and cardboard applications dropped. Still, refiners' total shipments grew by about three percent despite recession, which commonly depresses paper demand.

Although the U.S. papermaking industry is the largest in the world, it still represents only 37 percent of the paper and paperboard produced. The changes taking place in the United States are also occurring internationally, where statistics show a 17 percent increase in printing and writing paper production and a 30 percent climb in packaging papers between 1987 and 1990. This growth more than offset a 15 percent decline in other papers in the same period.

For example, papermakers in the growing Asian industry are shifting to higher quality products, coated stocks and alkaline processes, producing more demand for binders and sizings. While corn starches are used in other nations' industries, they have not achieved the dominance overseas that they have in the U.S. Changes in foreign papermaking, if coupled with trade reforms that open markets, could provide U.S. corn refiners with major new market potential in Asia, in Latin America, and elsewhere.

Meanwhile, technical progress—in which corn starch manufacturers are key players—and economic growth will mean continued development in the U.S. paper industry.

Domestically or internationally, paper figures to be a major market for corn starches for years to come.

Corn: Food, Seed and Industrial Uses

Year	HFCS	Glucose and Dextrose	Starch	Fuel Alcohol	Beverage Alcohol	Cereals and other products	Seed	Total
				Million bushels				
1980	165	156	151	35	78	54	20	659
1981	183	160	146	86	86	53	19	733
1982	214	165	150	140	110	60	15	854
1983	265	167	170	160	88	70	19	930
1984	310	167	172	232	84	81	21	1,067
1985	327	169	190	271	83	93	19	1,152
1986	338	171	214	290	85	109	16	1,223
1987	358	173	226	279	77	113	17	1,243
1988	361	182	223	287	107	114	19	1,293
1989	368	193	230	321	109	115	19	1,355
1990	379	200	232	343	80	114	19	1,367
1991	388	207	237	343	81	116	20	1,392

Source: USDA—Economic Research Service
Year beginning Sept. 1

U.S. Corn for Grain: Yield and Production

State	Area Harvested			Yield			Production		
	1989	1990	1991	1989	1990	1991	1989	1990	1991
	1,000 Acres			*Bushels*			*1,000 Bushels*		
AL	180	240	210	81	58	80	14,580	13,920	16,800
AZ	13	7	5	145	160	170	1,885	1,120	850
AR	58	73	80	122	95	100	7,076	6,935	8,000
CA	185	160	115	160	160	160	29,600	25,600	18,400
CO	930	830	840	145	155	153	134,850	128,650	128,520
DE	133	172	169	100	115	106	13,300	19,780	17,914
FL	80	75	75	74	71	68	5,920	5,325	5,100
GA	550	550	550	95	68	100	52,250	37,400	55,000
ID	50	30	63	125	130	125	6,250	3,900	7,875
IL	10,750	10,400	11,000	123	127	107	1,322,250	1,320,800	1,177,000
IN	5,200	5,450	5,450	133	129	92	691,600	703,050	510,600
IA	12,250	12,400	12,200	188	126	117	1,445,500	1,562,400	1,427,400
KS	1,240	1,450	1,650	125	130	125	155,000	188,500	206,250
KY	1,180	1,200	1,250	116	100	89	136,880	120,000	111,250
LA	142	186	247	95	116	85	13,490	21,576	20,995
MD	400	450	450	110	118	95	44,000	53,100	42,750
MI	1,970	2,070	2,300	113	115	100	222,610	238,050	253,000
MN	5,600	6,150	6,000	125	124	120	700,000	762,600	720,000
MS	140	140	150	70	80	75	9,800	11,200	11,250
MO	2,290	1,960	2,200	96	105	97	219,840	205,800	213,400
MT	4	9	15	80	95	120	320	855	1,800
NE	7,000	7,300	7,800	121	128	127	847,000	934,400	990,600
NJ	71	75	77	102	118	110	7,242	8,850	8,470
NM	60	55	60	160	145	165	9,600	7,975	9,900
NY	570	620	660	93	98	98	53,010	60,760	64,680
NC	950	1,070	950	93	68	90	88,350	72,760	85,500
ND	465	460	570	75	80	90	34,875	36,800	51,300
OH	2,900	3,450	3,400	118	121	96	342,200	417,450	326,400
OK	78	88	85	120	114	110	9,360	10,032	9,350
OR	22	18	15	160	150	146	3,520	2,700	2,190
PA	960	970	860	103	113	75	98,880	109,610	64,500
SC	340	320	255	91	45	85	30,940	14,400	21,675
SD	2,650	3,000	3,250	72	78	74	190,800	234,000	240,500
TN	530	510	510	107	86	86	56,710	43,860	43,860
TX	1,400	1,450	1,500	106	90	110	148,400	130,500	165,000
UT	20	19	21	132	140	140	2,640	2,660	2,940
VA	365	365	335	110	100	84	40,150	36,500	28,140
WA	90	80	80	175	175	180	15,750	14,000	15,840
WV	46	50	38	95	105	75	4,370	5,250	2,850
WI	2,800	3,000	3,200	111	118	119	310,800	354,000	380,800
WY	41	50	49	95	120	119	3,895	6,000	5,831
US	64,703	66,952	68,842	116.3	118.5	108.6	7,525,493	7,933,068	7,474,480

Source: USDA

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